Effect of Packet Size and Channel Capacity on the performance of EADARP Routing Protocol for Multicast Wireless ad hoc Networks

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ABSTRACT

EADARP is an Energy Adaptable Distance Aware Routing Protocol (EADARP) for wireless mobile ad hoc networks is developed to improve basic performance metrics for multicast protocols This paper investigates the effect of changing packet size and channel capacities on the performance of EADARP . Simulation program was developed using Glomosim to study such effect The results showed that a bigger packet size consumes more energy, and that a bigger packet size leads to less TTL expired, also smaller channel capacity leads to more power consumption.

1. INTRODUCTION

Wireless communications has two types; fixed or mobile. The fixed wireless communication is often called cellular networks, in which communication is achieved through a fixed number of base stations whose locations are known. The capacity of the channel given to a single session in a wireless cellular system can be either a point-to-point or a multipoint communication. Sharing the wireless cellular communication system capacity among multiple users is accomplished through various access methods, such as time division multiple access (TDMA), frequency division multiple access (FDMA) and code division multiple access (CDMA) [1- 4].

Mobile wireless communication; also called mobile ad hoc networks; does not have a fixed infrastructure or centralized administration. Each host in the mobile ad hoc network communicates with the other hosts via packet radios to form a temporary network its infrastructure varies according to the hosts' mobility.

The way of routing information in ad hoc networks is divided into two parts: *route discovery* and *route maintenance*. In route discovery, a host that wants to send information to another host must discover initially a suitable route for transmitting packets to the destination host. In route maintenance, the route should continue to send packets to the destination if the conditions remained unchanged. Otherwise, if the status of the links or hosts used in this route changed, some changes may be done to the route or there is a need to discover a new route [4-6].

The applications of wireless ad hoc networks determine if a communication session should be unicast (one-to-one), multicast (one-to-many), broadcast (one-to-all) or group communication (many-to-many). The rise in the number of mobile users has led to a wide variety of applications to become available. Some of these new applications depend on multicast communication to perform their operation. Multicasting has been implemented to the wireless ad hoc networks to make benefit from the dynamically reconfigurable nature of these wireless ad hoc networks [7-9].

A multicast protocol implemented in an ad hoc network should have the ability to connect all group members and then to maintain this connectivity after topological changes in the network [10-16]. Multicast ad hoc networks is the focus in this paper. Since multicast mobile ad hoc networks face the same constraints as unicast ad hoc networks, the efficient utilization of routing packets and energy efficiency must be taken into consideration when routing packets and recovering route breaks in multicast ad hoc networks. Some papers have considered minimum energy multicast routing in wireless multihop ad hoc networks, and for this purpose, a concept such as virtual relay [17-20] have been proposed. Also, several algorithms for energy efficient multicasting in static wireless ad hoc networks has been presented [21,22]. Energy efficient adaptation of multicast protocols in power controlled wireless ad hoc networks is the basic idea presented in [21- 26].

An Energy Adaptable Distance Aware Routing Protocol (EADARP) for wireless mobile ad hoc networks is developed in [27] to improve basic performance metrics for multicast protocols The EADARP protocol is similar to ODMRP, a mesh-based protocol that employs the same concept of forwarding group, but here, the forwarding group is a set of nodes responsible for forwarding multicast data on the paths selected based on the most efficient path in terms of distance and energy between any member pairs with two enhancements added: first, the network bandwidth is increased according to the need, second, the nodes' level of energy is adjusted if there is a must.

The EADARP shows better performance such as number of TTL expired, number of unreachable nodes when compared to other multicast protocols . In this paper the effect of changing packet size and channel capacity on the performance of EADARP are thoroughly investigated and the results are presented and discussed .

2. EADARP DESCRIPTION

The EADARP protocol [27] is similar to ODMRP, a mesh-based protocol that employs the same concept of forwarding group, but here, the forwarding group is a set of nodes responsible for forwarding multicast data on the paths selected based on the most efficient path in terms of distance and energy between any member pairs with two enhancements added: first, the network bandwidth is increased according to the need, second, the nodes' level of energy is adjusted if there is a must. In EADARP route selection, a multicast receiver selects the most stable route having the largest remaining energy, in other words, selecting the route with the highest lifetime. Finding the route having the highest lifetime is done by measuring each route's nodes lifetimes, and choosing the node with the least lifetime in each route, and then selecting the route having the node with the highest lifetime among the least energy remaining nodes. Then eliminating the nodes having energy below the level required (energy threshold level) in the selected route, for the purpose of avoiding route breakage if these nodes fail. But the eliminated nodes do not include neither the source node nor the destination node, to preserve the original route. After that, some nodes are eliminated between the source node and the destination node to make the selected route shorter, in other terms, reducing the path length leads to decreasing the power consumption during the transmission. Then, EADARP performs adjustments of nodes batteries power levels when required, and also it increases the network bandwidth when there is a congestion in traffic and decreases it when there is no traffic.

To select a route, a multicast receiver must wait for an appropriate amount of time after receiving the first JOIN QUERY so that all possible routes and their lifetimes will be known. The receiver then chooses the most stable route and broadcasts a JOIN REPLY.

3. SIMULATION ENVIRONMENT

We are going to describe the simulation environment in which we simulated the multicast protocols, and produced the results which are compared after that to conclude the characteristics of each protocol.

3.1. Description of the Simulation Model

Several important parts of the simulation environment are going to be described below, including the model itself, channel and radio model we used here, Medium Access Control protocol, multicast protocols used here, parameter values used in the simulation, the traffic pattern and the mobility model.

For evaluating the effect of changing packet size and channel capacity on the performance of EADARP, a simulation program was developed within the GloMoSim library [28]. The GloMoSim library is a scalable simulation environment for wireless network systems using the parallel discrete-event simulation capability provided by PARSEC [29].

The simulation is based on modeling a network of 30 mobile hosts placed uniformly within a 1000 m×1000 m area. Radio propagation range for each node was 250 m during all experiments. The used channel capacity is 8 Mbps when comparing the protocols with each others and when evaluating the performance of EADARP using different packet sizes. Each simulation is executed for 100 sec of simulation time. The network traffic loads used were between 100 packets/sec and 1500 packets/sec.

The IEEE 802.11 MAC with Distributed Coordination Function (DCF) [30] was used as the MAC protocol. DCF is the mode which allows nodes to share the wireless channel in an ad hoc configuration. The specific access scheme is Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) with acknowledgments.

3.2. Performance Metrics

The following performance metrics are proposed to evaluate the performance of EADRARP protocol:

3.2.1. Efficiency

Efficiency is the ratio of the number of data packets delivered to the destinations versus the number of data packets supposed to be received. This number presents the effectiveness of a protocol. Efficiency is also called the packet delivery ratio.

Efficiency = Total number of delivered packets/Total number of sent packets (calculated at each node) for all nodes and then the sum of ratios is divided by the number of active nodes.

3.2.2. Total number of control packets

It is the total number of control packets delivered during packets transmission in the network. Control packets include: beacons, route updates, join requests, acknowledgments, ------ etc.

Total number of control packets = beacons + CTRL + acknowledgments + join requests + join tables + route updates packets for all nodes.

3.2.3. Total power consumed

It is the sum of the power consumed at each node measured in mw/hr (milli watts per hour) during packets transmission in the network.

Total power consumed = The sum of power consumed for all nodes = $Pow_{.node1}$ +-----+ $Pow_{.node30}$

3.2.4. Total number of collisions

It is the total number of collisions that occurred during packets transmission in the network.

Total number of collisions = The sum of collisions for all nodes = $Coll_{.node1}$ +----+ $Coll_{.node30}$

3.2.5. Total number of unreachable nodes

It is the total number of unreachable nodes during packets transmission in the network.

Total number of unreachable nodes = The sum of unreachable nodes for all nodes = $Unreach_{.node1}$ +------+ $Unreach_{.node30}$

3.2.6. Total number of TTL (Time-To-Live) expired

It is the total number of TTL (Time-To-Live) expired during packets transmission in the network.

Total number of TTL expired = The sum of TTL expired for all nodes = $TTL\_exp_{.node1}$ +------+ $TTL\_exp_{.node30}$

4. EFFECT OF PACKET SIZE ON THE PERFORMANCE OF EADARP

In this section we evaluate the effect of increasing the packets size on the performance of EADARP under different network traffic loads beginning from 100 packets/second to 1500 packets/second. Packet sizes were taken respectively as: 64 bytes, 512 bytes, 1460 bytes and 2048 bytes. The results are discussed below.

4.1 Efficiency

Figure 1 illustrates the efficiency of EADARP using a variable packet sizes under different network traffic loads. EADARP shows a similar behavior using different number of packets sizes, whatever the packet size is, EADARP begins with a lower efficiency and the efficiency increases at a traffic load of 300 packets/second and decreases at a traffic load of 500 packets/second and becomes fixed between a network traffic load of 500 packets/second till 1500 packets/second. EADARP with 64 bytes packets and 2048 bytes packets provides better performance, and then followed by 512 bytes packets, and finally EADARP with 1460 bytes packets providing worst performance.
This was expected due to the fact that at a traffic load of 300 packets/second, the EADARP protocol exhibits the best efficiency before reaching the saturation point. Also, that increasing packet sizes could provide better efficiency to some extent as 2048 bytes packets shows better efficiency.

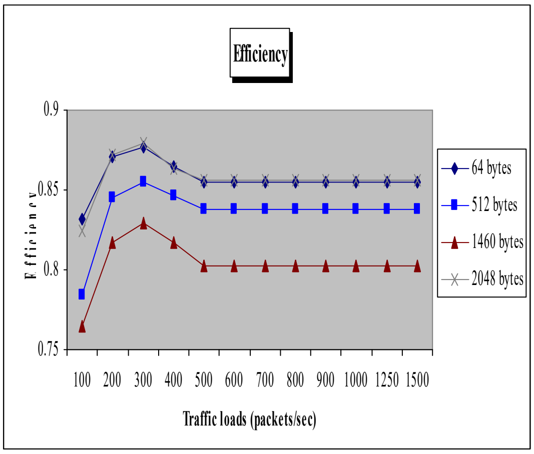

Figure 1: The efficiency of EADARP vs Traffic Load

4.2 Total number of control packets

Figure 2 illustrates the total number of control packets issued by EADARP under a variable network traffic loads using different packet sizes. EADARP with 2048 bytes packets shows better performance than with other packets sizes, followed by the other three packets sizes. The differences in the total number of issued control packets between 64 bytes, 512 bytes and 1460 bytes packet sizes is very small. The performance of EADARP using the preceding packet sizes is similar in terms that they begin with a smaller number of control packet at a traffic load of 100 packets/second and end with a higher number of control packets at a traffic load of 1500 packets/second, also, the total number of control packets is the same between a traffic load of 500 packets/second to a traffic load of 1500 packets/second. This means that the biggest packet size issues less number of control packets.
This was expected due to the fact that increasing the packet sizes has no great effect on the total number of control packets.

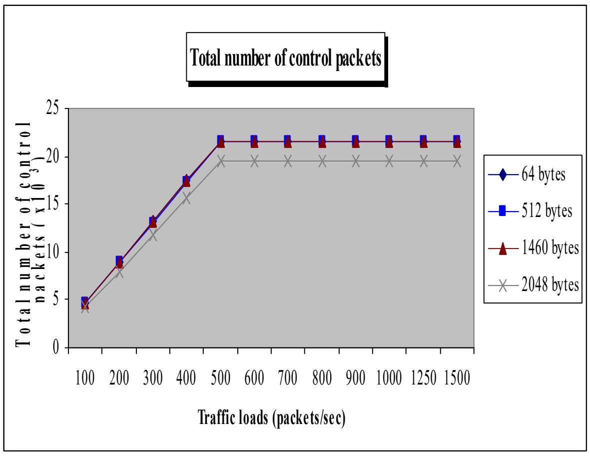

Figure 2: The total number of control packets vs Traffic Load

4.3 Total power consumed

Figure 3 illustrates the total power consumed in EADARP during packets' transmission using different packet sizes. The performance of EADARP in terms of power consumed using different packet sizes is the same, because EADARP begins with a lower value for power consumed when the traffic load is lower and this value increase as the traffic load increases and reaches 1500 packets/second, another notice is that the .ower consumed is fixed between a traffic load of 500 packets/second till a traffic load of 1500 packets/second and the differences between the values of the power consumed when changing the packet sizes is small. But in general, EADARP with a 2048 bytes packets consumed more energy., followed by 1460 bytes packets, then by 512 bytes packets, and finally by 64 bytes packets. So, EADARP with 2048 bytes packets is the worst performer, and EADARP with a 64 bytes packets is the best performer. This means that a bigger packet size makes our EADARP consumes more power.

This was expected due to the fact that longer packet sizes need more energy to be transmitted, then resulting in higher power consumed.

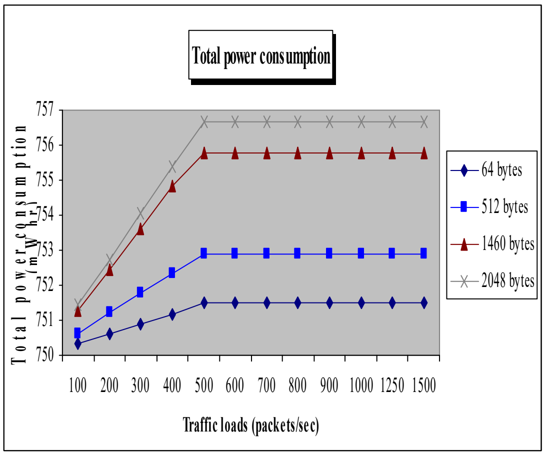

Figure 3: The total power consumed vs Traffic Load

4.4 Total number of collisions

Figure 4 illustrates the total number of collisions issued by EADARP under different traffic loads using different packet sizes. EADARP behavior is similar under different traffic loads using different packet sizes, because it begins with a lower number of collisions when the traffic load is low and the

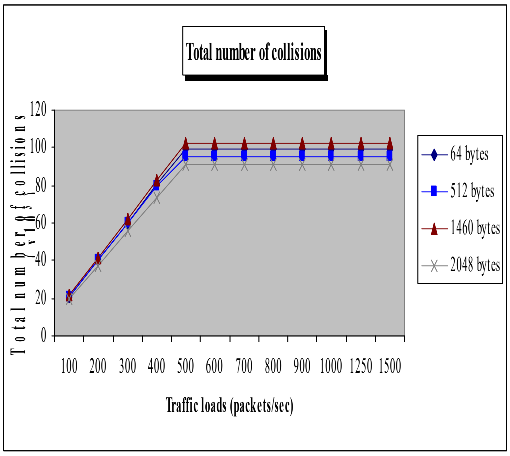

Figure 4: Total number of collisions vs Traffic Load

number of collisions increases as the traffic load reaches 1500 packets/second , also, the number of collisions becomes fixed between a traffic load of 500 packets/second and a traffic load of 1500 packets/second. The values of the number of collisions under different packet sizes are very close, but EADARP with 2048 bytes packets has the least number of collisions in comparison with the other three packet sizes. This was expected due to the fact that increasing packet sizes has no important effect on the total number of collisions, since collisions occur due to increased network traffic not due to packets sizes.

4.5 Total number of unreachable nodes

Figure 5 illustrates the number of unreachable nodes in EADARP under different network traffic loads using different packet sizes. EADARP under different network traffic loads changing from 100 packets/second to 1500 packets/second using different packets sizes gives the same number of unreachable nodes which is zero. This means that changing the packet size does not affect the number of unreachable nodes, and that none of the nodes were missed during packets' transmission in EADARP.

This was expected due to the fact that increasing packet sizes does not the protocol operation, then not affecting the number of nodes that can't be reached by other nodes. And this represents a good point in the EADARP protocol.

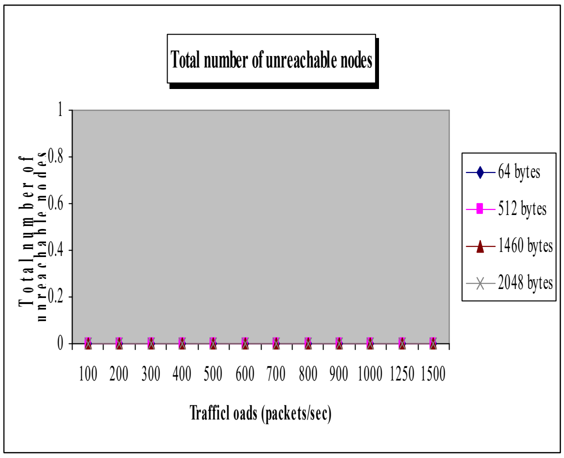

Figure 5: The number of unreachable nodes vs Traffic Load

4.6 Total number of TTL expired

Figure 6 illustrates the total number of TTL expired in EADARP during packets' transmission under different traffic loads using different packet sizes. EADARP with a 64 bytes packets has the highest number of TTL expired during packets' transmission, followed by 512 bytes packets, then by 1460 bytes packets, and finally by 2048 bytes packets. EADARP under different traffic loads using different packet sizes shows the same performance, because it begins with a smaller number of TTL expired when the traffic load is 100 packets/second and ends with a higher number of TTL expired when the traffic load is 1500 packets/second, also the number of TTL expired becomes fixed from a traffic load of 500 packets/second till the end of the simulation when the traffic load reaches 1500 packets/second. Another notice, is that the number of TTL expired in EADARP using different packets sizes between traffic loads of 100 packets/second to 500 packets/second is very close and between traffic loads of 500 packets/second and 1500 packets/second the difference between the number of TTL expired for each packet size increases a little. Also, we noticed that a bigger packet size means a smaller number of TTL expired.

This was expected due to the fact that when the packet size increases, it will cause nodes wanting to join a multicast group easier, resulting in a shorter waiting time for a node to join a group and then to a smaller number of TTL (Time-To-Live) expired. But at a traffic load of 500 packets/second, the EADARP protocol reaches its saturation point and can not accept more traffic loads, since every packet transmitted to one node is retransmitted as it is without changes.

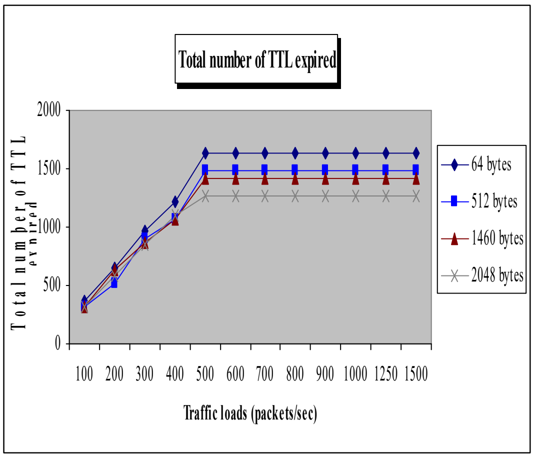

Figure 6: Total number of TTL expired vs Traffic Load

5. EFFECT OF CHANNEL CAPACITY ON THE PERFORMANCE OF EADARP

In this section we evaluate the effect of increasing the channel capacities on the performance of EADARP under different network traffic loads beginning ranging from 100 packets/second to 1500 packets/second. Channel capacities were taken respectively as: 3 Mbytes, 5 Mbytes, 7 Mbytes and 9 Mbytes, and the results of the simulation are discussed and evaluated.

5.1 Efficiency

Figure 7 illustrates the efficiency of EADARP under different network traffic loads using a variable channel capacities. EADARP with a 3 Mbytes channel capacity shows the worst performance with the lowest efficiency, followed by 5 Mbytes channel capacity, then by 9 Mbytes channel capacity, and finally by 7 Mbytes channel capacity which is the best performer. We notice that the values of efficiency in the 5 Mbytes, 9 Mbytes, and 7 Mbytes are very close, and that the efficiency of EADARP at 3 Mbytes is a little far from them. EADARP under different network traffic loads using different channel capacities shows similar performance, in terms that it begins with a lower efficiency at a traffic load of 100 packets/second, and the value of the efficiency increases when the traffic load reaches 300 packets/second, then decreases at a traffic load of 500 packets/second, and it becomes fixed at a traffic load of 500 packets/second until 1500 packets/second.

The channel capacity of 3 Mbytes to have the lowest efficiency was expected during the simulation. This was expected due to the fact that increasing the channel capacity could make packets' transmissions easier, thus reducing the packets' loss during the simulation and causing the efficiency to improve. The efficiency becomes fixed from the traffic load of 500 packets/second because the EADARP protocol reaches its saturation point and can not accept more traffic loads.

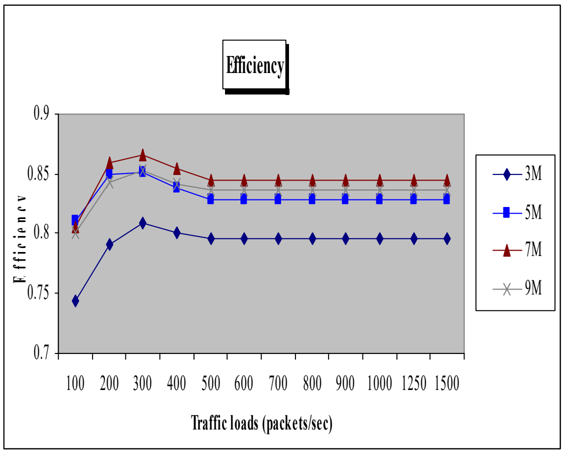

Figure 7: The efficiency of EADARP vs Traffic Load

5.2 Total number of control packets

Figure 8 illustrates the total number of control packets transmitted by EADARP under different network traffic loads using a variable channel capacities. EADARP has approximately the same total number of control packets under different network traffic loads using different channel capacities, and it shows the same behavior under a variable channel capacity, since it begins with a smaller total number of control packets at the beginning of the simulation at a traffic load of 100 packets/second, the total number of control packets increases as the network traffic load reaches 500 packets/second and this number becomes fixed between network traffic loads ranging from 500 packets/second to 1500 packets/second. We can interpret from the above figure that increasing channel capacities has no effect on the total number of control packets transmitted.

This was expected due to the fact that changing the channel capacity does not affect the protocol operation, since the total number of control packets transmitted during the simulation depend upon the protocol steps not on the environment in which the nodes reside.

5.3 Total power consumed

Figure 9 illustrates the total power consumed during packets' transmission in EADARP under different traffic loads using a variable channel capacities. EADARP performance under different traffic loads using a variable channel capacities is the same, because it begins with a smaller value for the total power consumed when the traffic load is 100 packets/second, then this value increases when the traffic load reaches 500 packets/second, and then it becomes fixed between traffic loads ranging from 500 packets/second to 1500 packets/second. EADARP with a channel capacity of 3 Mbytes

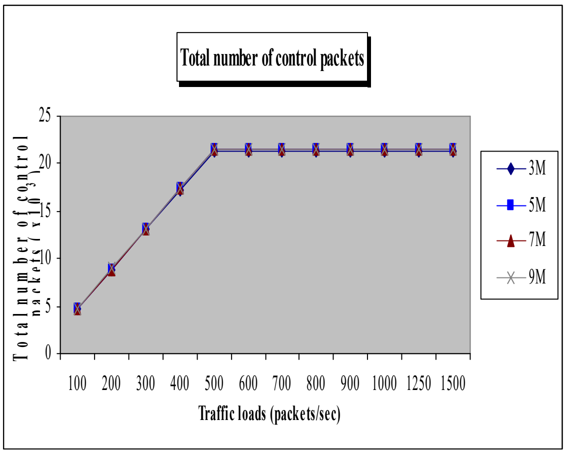

Figure 8: The total number of control packets vs Traffic Load

consumes more power, followed by 5 Mbytes, then by 7 Mbytes, and finally by 9 Mbytes, this means that EADARP with smaller channel capacities leads to more power consumption, but in general, the differences in EADARP power consumption under different traffic loads using variable channel capacities are not very big.

This was expected due to the fact that increasing the channel capacity makes packets' transmission easier in the network, thus a little less effort is done during the transmission due to reduced collisions, retransmissions and TTL expired, thus causing a reduction in the total power consumed during the simulation.

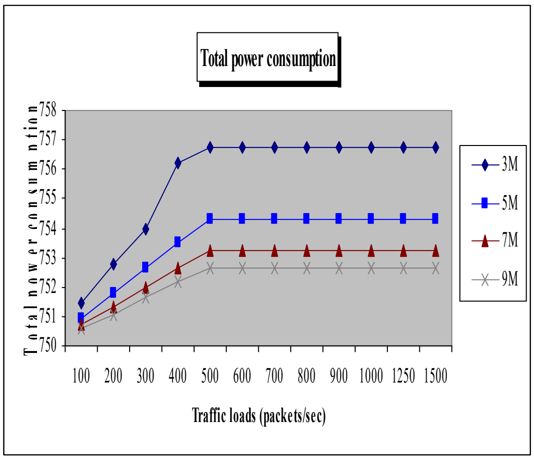

Figure 9 The total power consumed vs Traffic Load

5.4 Total number of collisions

Figure 10 illustrates the total number of collisions in EADARP under different network traffic loads using different channel capacities. EADARP has approximately the same total number of collisions under different network traffic loads ranging from 100 packets/second to 1500 packets/second using variable channel capacities. It performs in the same manner when using different channel capacities, because it begins with a lower number of collisions when the traffic load is 100 packets/second and ends with a higher number of collisions when the traffic load reaches 500 packets/second and becomes fixed between traffic loads ranging from 500 packets/second to 1500 packets/second. There is a reduction in the total number of collisions when increasing the channel capacity respectively from 3 Mbytes to 9 Mbytes, but, in general the change in the total number of collisions is not too big.

This was expected due to the fact that increasing the channel capacity result in packets' transmission more easily inside the network, thus resulting in a lower possibility of packets to collide, and in a smaller number of collisions.

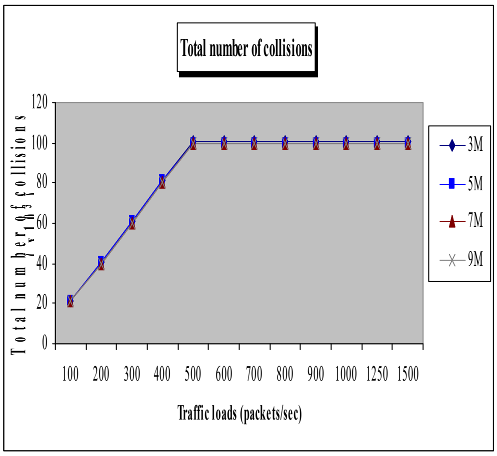

Figure 10: The total number of collisions vs Traffic Load

5.5 Total number of unreachable nodes

Figure 11 illustrates the total number of unreachable nodes during packets' transmission in EADARP under different network traffic loads using different channel capacities. EADARP has zero unreachable nodes under different network traffic loads ranging from 100 packets/second to 1500 packets/second using varying channel capacities: 3 Mbytes, 5 Mbytes, 7 Mbytes and 9 Mbytes. EADARP performance shows that varying channel capacities has no effect on the total number of unreachable nodes.

This was expected due to the fact that increasing the channel capacity does not have an effect on the total number of unreachable nodes, since the channel capacity does not change neither the protocol operation nor the effective traffic load being transmitted.

5.6Total number of TTL expired

Figure 12 illustrates the total number of TTL expired during packets' transmission in EADARP under different network traffic loads using different channel capacities. The total number of TTL expired is very close using different channel

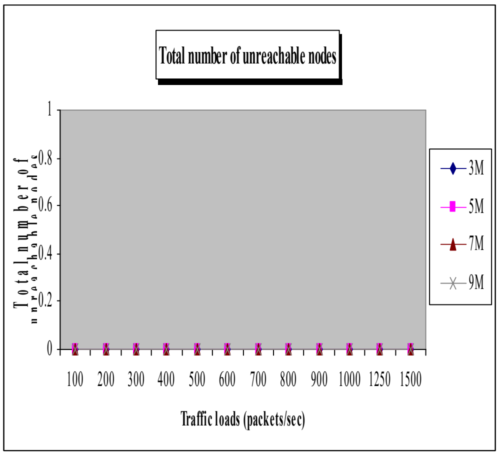

Figure 11: The total number of unreachable nodes vs Traffic

capacities in the first three cases, but the channel capacity of 9 Mbytes has the lowest number of TTL expired. EADARP shows similar performance under different network traffic loads using different channel capacities, because it begins with a lower number of TTL expired at a traffic load of 100 packets/second and this number increases as the traffic load reaches 500 packets/second and becomes fixed from network traffic loads ranging between 500 packets/second to 1500 packets/second.

This was expected due to the fact that increasing the channel capacity has not a great effect on the total number of TTL expired, since channel capacity does not change the effective traffic load. But in general, bigger channel capacity makes packets' transmission easier, then resulting in a smaller number of TTL expired, as in the case of the channel capacity of 9 Mbytes.

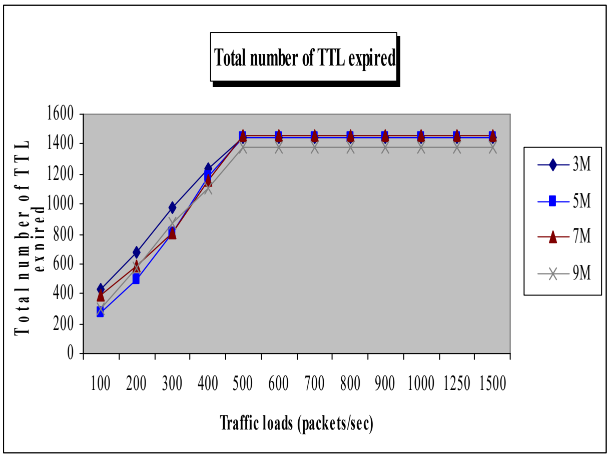

Figure 12: The total number of TTL expired vs Traffic Load

6. CONCLUSION

EADARP is an Energy Adaptable Distance Aware Routing Protocol (EADARP) for wireless mobile ad hoc networks is developed to improve basic performance metrics for multicast protocols . This paper investigates the effect of changing packet size and channel capacities on the performance of EADARP . Simulation program was developed using Glomosim to study such effect The results showed that a bigger packet size consumes more energy, and that a bigger packet size leads to less TTL expired, also smaller channel capacity leads to more power

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